

BETA-PINENE

CASRN: 127-91-3

For other data, click on the Table of Contents

Human Health Effects:

Human Toxicity Excerpts:

/HUMAN EXPOSURE STUDIES/ ... Eight male volunteers were exposed to 450 mg/cu m turpentine by inhalation (2 hr, 50 W) in an exposure chamber. ... The mean relative uptakes of alpha-pinene, beta-pinene, and 3-carene were 62%, 66%, and 68% respectively, of the amount supplied. ... After experimental exposure to turpentine an increase in airway resistance was found that differed significantly from results of exposure to 3-carene at 10 mg/cu m ($P = 0.021$) or 450 mg/cu m ($P = 0.047$). ... Acute effects show small, if any, interactions between alpha-pinene, beta-pinene, and 3-carene. The subjects experienced discomfort in the throat and airways during exposure to turpentine and airway resistance was increased after the end of exposure.

[Filipsson AF; Occup Environ Med 53 (2): 100-5 (1996)] **PEER

REVIEWED** [PubMed Abstract](#)

/SIGNS AND SYMPTOMS/ Absorption of large doses may result in delirium, ataxia, & kidney damage. Inhalation may cause palpitation, dizziness, nervous disturbances, chest pain, bronchitis, and nephritis. /Pinene/

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3243] **PEER REVIEWED**

/SIGNS AND SYMPTOMS/ Harmful by inhalation, in contact with skin and if swallowed. Irritating to eyes, respiratory system and skin. May cause sensitization by skin contact. Harmful: may cause lung damage if swallowed. /(-)-Beta-pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]

PEER REVIEWED

/CASE REPORTS/ A patient attempting suicide ingested 400-500 mL pine oil and was admitted to the clinic. Since more than the lethal dose had been ingested hemoperfusions with activated charcoal and amberlite and a hemodialysis were performed. The composition of the ingested pine oil was determined by gas chromatography/mass spectrometry. Four monoterpenes were identified: 57% alpha-pinene, 8% beta-pinene, 26% carene, 6% limonene and 3% other hydrocarbons. The blood and urine monoterpene concentrations were continuously monitored. The data suggest that monoterpenes are poorly resorbed in the gastrointestinal tract. The resorbed portion of the hydrocarbons cumulates in the lipophilic body compartments and is slowly metabolized and then excreted by the kidneys. The main metabolic pathways are hydration, hydroxylation, rearrangement, and acetylation. Five metabolites were identified.

[Koppel C et al; Arch Toxicol 49 (1): 73-8 (1981)] **PEER REVIEWED**

[PubMed Abstract](#)

/EPIDEMIOLOGY STUDIES/ ... To study work exposure and respiratory symptoms in

New Zealand plywood mill workers ... personal inhalable dust (n = 57), bacterial endotoxin (n = 20), abietic acid (n = 20), terpene (n = 20) and formaldehyde (n = 22) measurements were taken and a respiratory health questionnaire was administered to 112 ... workers. ... Twenty-six percent of the dust exposures exceeded 1 mg/cu m, however, none of the samples exceeded the legal limit of 5 mg/cu m (geometric mean (GM) = 0.7 mg/m³, geometric standard deviation (GSD) = 1.9). Workers in the composer area (where broken sheets are joined together) were significantly (P < 0.01) more highly exposed. Endotoxin levels were low to moderate (GM = 23.0 EU/cu m, GSD = 2.8). Abietic acid levels ranged from 0.3 to 2.4 ug/cu m (GM = 0.7 ug/cu m, GSD = 1.8) and were significantly (P < 0.05) higher for workers in the composer area of the process. Geometric mean levels of alpha-pinene, beta-pinene and Delta(3)-carene were 1.0 (GSD = 2.7), 1.5 (GSD = 2.8) and 0.1 (GSD = 1.4), respectively, and alpha-pinene and beta-pinene levels were significantly (P < 0.001) higher for workers in the 'green end' of the process, up to and including the veneer dryers. Formaldehyde levels ranged from 0.01 to 0.74 mg/cu m (GM = 0.08 mg/cu m (= 0.06 ppm), GSD = 3.0). Asthma symptoms were more common in plywood mill workers (20.5%, n = 112) than in the general population (12.8%, n = 415, adjusted OR (95% CI) = 1.5 (0.9-2.8)). Asthma symptoms were associated with duration of employment and were reported to lessen or disappear during holidays. No clear association with any of the measured exposures was found, with the exception of formaldehyde, where workers with high exposure reported more asthma symptoms (36.4%) than low exposed workers (7.9%, adjusted OR (95% CI) = 4.3 (0.7-27.7))...

[Fransman W et al; Ann Occup Hyg 47 (4): 287-95 (2003)] **PEER REVIEWED** [PubMed Abstract](#)

Skin, Eye and Respiratory Irritations:

Irritating to eyes, respiratory system and skin... /(-)-Beta-pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]
PEER REVIEWED

...Irritant to skin and mucous membranes

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3243] **PEER REVIEWED**

Probable Routes of Human Exposure:

Occupationally, workers should be protected from inhaling pinene vapors and from direct skin contact. /Pinene/

[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994., p. 1289] **PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 77,244 workers (13,763 of these were female) were potentially exposed to beta-pinene in the US(1). Occupational exposure to beta-pinene may occur through inhalation and dermal contact

with this compound at workplaces where beta-pinene is produced or used(SRC). Monitoring and use data indicate that the general population may be exposed to beta-pinene via inhalation of ambient air and dermal contact with this compound or other products containing beta-pinene(SRC).

[(1) NIOSH; NOES. National Occupational Exposure Survey conducted from 1981-1983. Estimated numbers of employees potentially exposed to specific agents by 2-digit standard industrial classification (SIC). Available at <http://www.cdc.gov/noes/> as of Sept 25, 2008.] **PEER REVIEWED**

beta-Pinene median concentration levels for children who attended two inner-city schools in Minneapolis, MN were reported as 0.1, 0.1 and 2.5 ug/cu m outdoors, indoors at school and indoors at home, respectively, during winter, 2000; levels for spring 2000 were 0.1, 0.1 and 1.5 ug/cu m, respectively(1). Pinene concentration, both alpha- and beta- combined, ranged from not detected (2 mg/cu m) to 193 mg/cu m in workplace air from a thermomechanical pulp production plant(2). beta-Pinene workroom air level in Swedish saw sheds of sawmills processing Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) were reported at 6.3% relative to total terpene concentration during sawing of Scot's pine(3). Danish workers picking up household waste are susceptible because garden waste carried by garbage trucks emits beta-pinene into the surrounding air(4).

[(1) Adgate JL et al; Environ Health Perspect 112: 1386-92 (2004) (2) Goyer N; Appl Occup Environ Hyg 9: 428-32 (1994) (3) Svedberg U, Galle B; Appl Occup Environ Hyg 15: 686-94 (2000) (4) Wilkins K, Larsen K; Chemosphere 32: 2049-55 (1996)] **PEER REVIEWED**

Average Daily Intake:

Consumption: Annual 7833.33 lbs; Individual: 0.006638 mg/kg/day

[Burdock, G.A. (ed.). Fenaroli's Handbook of Flavor Ingredients. 5th ed. Boca Raton, FL 2005, p. 1586] **PEER REVIEWED**

Minimum Fatal Dose Level:

3. 3= MODERATELY TOXIC: PROBABLE ORAL LETHAL DOSE (HUMAN) 0.5-5 G/KG, BETWEEN 1 OUNCE & 1 PINT (OR 1 LB) FOR 70 KG PERSON (150 LB). /PINENE/

[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976., p. II-170] **PEER REVIEWED**

About 150 mL may constitute a human oral fatal dose. /Pinene/

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3242] **PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** TURPENTINE OIL ***, is relevant for this HSDB record chemical.

Life Support:

- o This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A) WITH POISONING/EXPOSURE

- 1) INGESTION - Ingestion is the most significant route of exposure. Turpentine oil is readily absorbed.
 - a) SYMPTOMS - Turpentine produces the following: burning, abdominal pain, vomiting, diarrhea, tachycardia, dyspnea, cyanosis and fever. Severe ingestions can cause glycosuria, hematuria, albuminuria, anuria, excitement, delirium, ataxia, vertigo, stupor, seizures and coma. Death is usually due to respiratory failure.
 - b) ONSET - usually 2 to 3 hours for systemic toxicity to develop.
 - c) DURATION - GI and CNS symptoms generally resolve within 12 hours in patients moderately exposed.
- 2) INHALATION - High vapor concentrations can cause mucous membrane irritation, hyperpnea, vertigo, tachycardia, headache, hallucinations, distorted perceptions, and seizures. Nephritis has been reported by some investigators as a result of acute or chronic vapor inhalation. Absence of renal effects from turpentine vapor exposure has also been reported.
 - a) Aspiration of turpentine following ingestion can

- occur, resulting in chemical pneumonitis and pulmonary edema.
- 3) DERMAL/INJECTION - Topical application produces a rubefacient effect, with redness, warmth, blisters and burns. Long term or repeated exposure can result in irritation. Some turpentine preparations cause contact dermatitis. Turpentine can be absorbed through the skin.
 - a) Subcutaneously injected turpentine can cause fever, cellulitis and sterile abscess. Pulmonary edema and local tissue inflammatory responses have occurred from turpentine administered either IV or as a vaginal douche.
 - 4) EYE - Ocular exposure to liquid turpentine causes conjunctivitis, lid edema, and blepharospasm. Allergy has been reported. High vapor concentrations produce irritation.
- 0.2.3 VITAL SIGNS
- 0.2.6 RESPIRATORY
- 0.2.6.1 ACUTE EXPOSURE
- A) WITH POISONING/EXPOSURE
 - 1) Inhalation of vapors may produce respiratory irritation. Aspiration pneumonitis, pulmonary necrosis, pneumatocele or pulmonary edema has developed after ingestion, IV injection, or the use of turpentine as a vaginal douche.
- 0.2.7 NEUROLOGIC
- 0.2.7.1 ACUTE EXPOSURE
- A) WITH POISONING/EXPOSURE
 - 1) Headache and dizziness may occur with vapor exposure. Seizures may develop after large ingestions. CNS depression including coma may occur following turpentine ingestion.
- 0.2.20 REPRODUCTIVE HAZARDS
- A) The use of turpentine and water as a vaginal douche has resulted in abortion.
- 0.2.21 CARCINOGENICITY
- 0.2.21.1 IARC CATEGORY
- A) IARC Carcinogenicity Ratings for CAS8006-64-2 (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2006; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2007; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2010; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2010a; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2008; IARC, 2004):
 - 1) Not Listed
- 0.2.21.2 HUMAN OVERVIEW
- A) Chronic turpentine exposure may lead to an increased risk of respiratory cancer when the duration of exposure exceeds 5 years (HSDB , 2000).
- 0.2.22 GENOTOXICITY
- A) At the time of this review, no genetic effects information were available.

Laboratory:

- A) No specific lab work (CBC, electrolytes, urinalysis) is needed unless otherwise clinically indicated.

Treatment Overview:

0.4.2 ORAL EXPOSURE

- A) Activated charcoal may cause vomiting and aspiration. It should be reserved for patients with large ingestions or significant coingestants. Protect patients airway with a cuffed endotracheal tube.
 - 1) ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
- B) SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).
 - 1) Consider phenobarbital or propofol if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
 - 2) Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.

0.4.4 EYE EXPOSURE

- A) DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

0.4.5 DERMAL EXPOSURE

- A) OVERVIEW
 - 1) DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

Range of Toxicity:

- A) ADULT - A dose of 120 to 180 milliliters may be fatal if no treatment is obtained.
- B) PEDIATRIC - A dose of 15 milliliters was fatal in a 2-year-old child; however, benzene was present in the mixture. Children have survived ingestions of 2 to 3 ounces.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2011; CCIS Volume 148, edition expires Aug, 2011. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2011; CCIS Volume 148, edition expires Aug, 2011.] **PEER REVIEWED**

Antidote and Emergency Treatment:

Immediate first aid: Ensure that adequate decontamination has been carried out. If patient

is not breathing, start artificial respiration, preferably with a demand valve resuscitator, bag-valve-mask device, or pocket mask, as trained. Perform CPR if necessary. Immediately flush contaminated eyes with gently flowing water. Do not induce vomiting. If vomiting occurs, lean patient forward or place on the left side (head-down position, if possible) to maintain an open airway and prevent aspiration. Keep patient quiet and maintain normal body temperature. Obtain medical attention. /Turpentine, terpenes, and related compounds/

[Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 244] **PEER REVIEWED**

Basic treatment: Establish a patent airway (oropharyngeal or nasopharyngeal airway, if needed). Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary Anticipate seizures and treat if necessary For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with 0.9% saline (NS) during transport Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. /Turpentine, terpenes, and related compounds/

[Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 244] **PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious, has severe pulmonary edema, or is in severe respiratory distress. Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial. Consider drug therapy for pulmonary edema Monitor cardiac rhythm and treat arrhythmias as necessary Start IV administration of D5W /SRP: "To keep open", minimal flow rate/. Use 0.9% saline (NS) or lactated Ringer's (LR) if signs of hypovolemia are present. For hypotension with signs of hypovolemia, administer fluid cautiously. Watch for signs of fluid overload Treat seizures with diazepam or lorazepam Use proparacaine hydrochloride to assist eye irrigation /Turpentine, Terpenes, and related compounds/

[Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 245] **PEER REVIEWED**

Animal Toxicity Studies:

Non-Human Toxicity Excerpts:

/LABORATORY ANIMALS: Acute Exposure/ ...Irritant to skin and mucous membranes ... May cause dermal eruption & occasional benign tumors. /Pinene/

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3244] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ ...A toxicity study of each of the major fragrant components of myoga /a fragrant plant cultivated throughout Japan/ using acute dermal irritation assays and the Guinea-Pig Maximization test (GPMT) /was conducted/ ...to probe the mechanism of allergic contact dermatitis /from this plant/. In acute dermal irritation assays, alpha-pinene, beta-pinene and limonene showed positive responses at concentrations of 4%; limonene oxide at 20% and myoga showed a positive response at concentrations of 100%. From the results of the GPMT, according to Kligman scores, limonene oxide was identified as an extreme skin sensitizer and myoga as a mild skin sensitizer. The results of the present study show that R-(+)-limonene is the most important allergen amongst the chemical components of myoga, and /was considered/ ... to be the reason why myoga cultivators experience allergic contact dermatitis.

[Wei Q et al; J Occup Health 48 (6): 480-6 (2006)] **PEER REVIEWED**

[PubMed Abstract](#)

/GENOTOXICITY/ The Ames reverse mutation assay of beta-pinene was conducted at concentrations of 0, 0.01, 0.05, 0.1, 0.5, 1.0, 2.5, and 5.0 uL/plate using TA100, TA98, TA1538, TA1537 and TA1535 with or without Aroclor induced rat liver microsomal enzyme preparations. Doses were selected based on a preliminary toxicity study of 14 doses ranging from 0.02 to 150.0 uL/plate using strain TA100. The test substance was completely toxic at doses at and above 4.69 uL/plate. DMSO was used as the solvent and the negative control. ... beta-Pinene did not exhibit mutagenic activity at any dose level tested.

[The Flavor and Fragrance High Production Volume Consortia; Revised Robust Summaries for Bicyclic Terpene Hydrocarbons Submitted to the EPA under the HPV Challenge Program. p.155 (November 9, 2006). Available from, as of October 8, 2008:

<http://www.epa.gov/chemrtk/pubs/summaries/bictrphy/c13610tc.htm> **PEER REVIEWED**

/GENOTOXICITY/ The Ames reverse mutation assay of beta-pinene was conducted at concentrations up to 5000 ug/plate using TA1535, TA1537, TA1538, TA98 and TA100 with and without Aroclor induced rat liver microsomal enzyme preparations. After 2 days incubation at 37 deg C, revertant colonies were counted. There was no evidence of mutagenicity.

[The Flavor and Fragrance High Production Volume Consortia; Revised Robust Summaries for Bicyclic Terpene Hydrocarbons Submitted to the EPA under the HPV Challenge Program. p.156 (November 9, 2006). Available from, as of October 8, 2008:

<http://www.epa.gov/chemrtk/pubs/summaries/bictrphy/c13610tc.htm> **PEER REVIEWED**

/GENOTOXICITY/ The Ames reverse mutation assay of beta-pinene was conducted at concentrations of 0.03, 0.3, 3 and 30 umoles/plate (4.08, 40.8, 408 and 4080 ug/plate) using TA98 and TA100 with and without Aroclor induced rat liver microsomal enzyme preparations. The solvent used was ethanol and the cytotoxic concentration was >3 umoles/plate. No mutagenic activity was observed.

[The Flavor and Fragrance High Production Volume Consortia; Revised Robust Summaries for Bicyclic Terpene Hydrocarbons Submitted to the EPA under the HPV Challenge Program. p.156-7 (November 9, 2006). Available

from, as of October 8, 2008:

<http://www.epa.gov/chemrtk/pubs/summaries/bictrphy/c13610tc.htm> **PEER
REVIEWED**

/GENOTOXICITY/ A sister chromatid exchange (SCE) assay of beta-pinene was conducted in Chinese hamster ovary (CHO K-1) cells at concentrations of 0, 3.3, 10, 33.3, 100, 333 and 1000 uM. The solvent was DMSO. The CHO K-1 cells were exposed to 0.15 micromolar mitomycin C for 21 hrs and cultured with the test substance for 1 cell cycle. beta-Pinene did not induce SCEs in CHO cells.

[The Flavor and Fragrance High Production Volume Consortia; Revised Robust Summaries for Bicyclic Terpene Hydrocarbons Submitted to the EPA under the HPV Challenge Program. p.160 (November 9, 2006). Available from, as of October 8, 2008:

<http://www.epa.gov/chemrtk/pubs/summaries/bictrphy/c13610tc.htm> **PEER
REVIEWED**

/OTHER TOXICITY INFORMATION/ To clarify the existence of a receptor protein for sensory irritants in trigeminal nerve endings, D- (i.e. (+)) and L- (i.e. (-)) enantiomers of alpha- and beta-pinene as models of nonreactive chemicals were evaluated for their potency in outbred OF1 and NIH/S mice using ASTM E981-84 bioassay. All pinenes possess sensory irritation properties and also induced sedation and signs of anesthesia but had no pulmonary irritation effects. According to the ratio of RD50 (i.e. concentration which causes a 50% decrease in respiratory rate,f) and vapor pressure (Po), all pinenes are nonreactive chemicals. For nonreactive chemicals, Po and olive oil-gas partition (Loil) can be used to estimate their potency as sensory irritant. Thus, for enantiomers with identical physicochemical properties, the estimated RD50 values are the same. In addition, although alpha- and beta-pinene do not have identical Po and Loil values, their estimated potencies are quite close. However, the experimental results showed that D-enantiomers of pinenes were the most potent as sensory irritants and a difference in potency also exists between alpha- and beta-pinene. RD50 for D-enantiomers of alpha- and beta-pinene were almost equal, 1053 ppm and 1279 ppm in OF1 strain and 1107 ppm and 1419 ppm in NIH/S strain, respectively. Values differed by a factor of approximately 4 to 5 from L-beta-pinene for which the RD50 was 4663 ppm in OF1 and 5811 ppm in NIH/S mice. RD50 could not be determined for L-alpha-pinene; this pinene was almost inactive. D-alpha-pinene seems to best fit the receptor because its experimental RD50 was one-half of the estimated value while for D-beta-pinene those values were equal. On the contrary, L-beta-pinene was about 3 to 4 times less potent than estimated. L-alpha-pinene was only slightly active although it was estimated to be as potent as D-alpha-pinene. The remarkable difference in potency between L-enantiomers is most likely due to a structural difference between alpha- and beta-pinene: the more flexible beta-pinene can bend to fit into the receptor better than the rigid alpha-pinene. The results showed that the commonly used physicochemical descriptors cannot fully explain the potency of these chemicals; their three-dimensional structure should also be considered. Because of the stereospecificity of pinenes, a target site for nonreactive sensory irritants is most likely a receptor protein containing a chiral lipophilic pocket.

[Kasanen JP et al; Arch Toxicol 72 (8): 514-23 (1998)] **PEER

REVIEWED** [PubMed Abstract](#)

Non-Human Toxicity Values:

LD50 Rat (Wistar) oral >5000 mg/kg

[The Flavor and Fragrance High Production Volume Consortia; Revised Robust Summaries for Bicyclic Terpene Hydrocarbons Submitted to the EPA under the HPV Challenge Program. p.141 (November 9, 2006). Available from, as of October 8, 2008:

<http://www.epa.gov/chemrtk/pubs/summaries/bictrphy/c13610tc.htm> **PEER REVIEWED**

LD50 Rat oral 4700 mg/kg

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 3099] **PEER REVIEWED**

LD50 Rabbit (New Zealand white) dermal (24 hr application) >5000 mg/kg

[The Flavor and Fragrance High Production Volume Consortia; Revised Robust Summaries for Bicyclic Terpene Hydrocarbons Submitted to the EPA under the HPV Challenge Program. p.145 (November 9, 2006). Available from, as of October 8, 2008:

<http://www.epa.gov/chemrtk/pubs/summaries/bictrphy/c13610tc.htm> **PEER REVIEWED**

Ecotoxicity Values:

LC50; Species: Green algae; Concentration: 1.44 mg/L for 48 hr /Conditions of bioassay not specified in source examined/

[USEPA; High Production Volume Information System (HPVIS). Detailed Chemical Results Chemical Name: beta-Pinene (127-91-3). Available from, as of October 13, 2008:

<http://iaspub.epa.gov/opptpv/quicksearch.display?pChem=101069> **PEER REVIEWED**

LC50; Species: Daphnia magna (Water flea); Conditions: freshwater, static, 20.1 deg C, pH 7.90 + or -0.05, oxygen concentration 8.2 mg/mL; Concentration: 1.25 mg/L for 48 hr /99% pure 1S(-)-isover. Measured purity 97%/

[USEPA; High Production Volume Information System (HPVIS). Detailed Chemical Results Chemical Name: beta-Pinene (127-91-3). Available from, as of October 13, 2008:

<http://iaspub.epa.gov/opptpv/quicksearch.display?pChem=101069> **PEER REVIEWED**

LC50; Species: Oncorhynchus mykiss (Rainbow trout, age 1-4 days); Conditions: freshwater, flow through, 10-11 deg C, pH 8.2, hardness 100 mg/L CaCO3, dissolved oxygen 90%; Concentration: 1400 ug/L for 60 days /99% purity/

[Passino-Reader DR et al; J.Gt.Lakes Res. 21(3):373-383 (1995) Available from, as of August 26, 2008:

http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Oncorhynchus mykiss (Rainbow trout, age 1-7 days); Conditions: freshwater, flow through, 10-11 deg C, pH 8.2, hardness 100 mg/L CaCO3, dissolved

oxygen 90%; Concentration: 930 ug/L for 60 days (95% confidence interval: 820-1000 ug/L) /99% purity/

[Passino-Reader DR et al; J.Gt.Lakes Res. 21(3):373-383 (1995)

Available from, as of August 26, 2008:

http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Pimephales promelas (Fathead minnow); Conditions: freshwater, semi-static, 24.2 deg C, pH 7.60 + or -0.1, oxygen concentration 6.6 mg/mL; Concentration: 0.50 mg/L for 96 hr /99% pure 1S(-)-isomer. Measured purity 97%/

[USEPA; High Production Volume Information System (HPVIS). Detailed Chemical Results Chemical Name: beta-Pinene (127-91-3). Available from, as of October 13, 2008:

<http://iaspub.epa.gov/opthpv/quicksearch.display?pChem=101069> **PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

The biotransformation of (+)-, (-)-, and (+-)-alpha-pinenes, (-)-beta-pinene (nopinene), (-)-cis-pinane, (+)-3-carene, (-)-cis-carane, myrcene, and p-cymene in rabbits was investigated. The major metabolites were as follows: (-)-trans-verbenol from (+)-, (-)-, and (+-)-alpha-pinenes; (-)-10-pinanol and (-)-1-p-menthene-7,8-diol from (-)-beta-pinene; (-)-alpha-terpineol and (-)-trans-sobrerol from (-)-cis-pinane; (-)-m-mentha-4,6-dien-8-ol, 3-carene-9-ol, (-)-3-carene-9-carboxylic acid, and 3-carene-9,10-dicarboxylic acid from (+)-3-carene; carane-9,10-dicarboxylic acid from (-)-cis-carane; and myrcene-3(10)-glycol, myrcene-1,2-glycol, uroterpenol, and p-cymene-9-carboxylic acid from p-cymene. These metabolisms include allylic oxidation, epoxidation, stereoselective gem-dimethyl hydroxylation and its oxidation, cleavage of a conjugated double bond by epoxidation, and regioselective oxidation, some of which are not found usually in chemical reactions, and due to which various new compounds were determined. This biotransformation of the monoterpene hydrocarbons gave some insect pheromones in high yield.

[Ishidata T et al; J Pharm Sci 70 (4): 406-15 (1981) Apr;70(4):406-15]

PEER REVIEWED [PubMed Abstract](#)

Absorption, Distribution & Excretion:

Pinene is easily absorbed through the pulmonary system, the skin, and the intestine.

/Pinene/

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3243] **PEER REVIEWED**

Following immersion of young pigs & one human subject for 30 minutes in baths containing 150 mL of a pine-oil mixture (Fichtennadel-Latschenkieferol Kneipp) in 450 L of water, alpha- & beta-pinene & limonene (components of Latschenkieferol) were detected in exhaled air within 20 minutes reaching maximum levels 50-75 minutes after

start of the bath & remaining detectable after 1 day.

[Opdyke, D.L.J. (ed.). Monographs on Fragrance Raw Materials. New York: Pergamon Press, 1979., p. 650] **PEER REVIEWED**

Interactions:

Beta-pinene vaporized from turpentine had no effect on hexobarbital sleeping time or parathion mortality in male rats, but increased heptachlor mortality and benzpyrene hydroxylation.

[SPERLING F ET AL; CHANGES IN LD50 OF PARATHION AND HEPTACHLOR FOLLOWING TURPENTINE PRETREATMENT; ENVIRON RES 5(2) 164 (1972)] **PEER REVIEWED**

Pharmacology:

Interactions:

Beta-pinene vaporized from turpentine had no effect on hexobarbital sleeping time or parathion mortality in male rats, but increased heptachlor mortality and benzpyrene hydroxylation.

[SPERLING F ET AL; CHANGES IN LD50 OF PARATHION AND HEPTACHLOR FOLLOWING TURPENTINE PRETREATMENT; ENVIRON RES 5(2) 164 (1972)] **PEER REVIEWED**

Minimum Fatal Dose Level:

3. 3= MODERATELY TOXIC: PROBABLE ORAL LETHAL DOSE (HUMAN) 0.5-5 G/KG, BETWEEN 1 OUNCE & 1 PINT (OR 1 LB) FOR 70 KG PERSON (150 LB).
/PINENE/

[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976., p. II-170] **PEER REVIEWED**

About 150 mL may constitute a human oral fatal dose. /Pinene/

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3242] **PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

beta-Pinene's production and use as an intermediate for perfumes and flavorings, in polyterpene resins, and as a fragrance ingredient may result in its release to the environment through various waste streams. beta-Pinene is a natural hydrocarbon emission product from softwood trees, in particular spruce. If released to air, a vapor pressure of 2.93 mm Hg at 25 deg C indicates beta-pinene will exist solely as a vapor in

the atmosphere. Vapor-phase beta-pinene will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 4.9 hours. Vapor-phase beta-pinene will be degraded in the atmosphere by reaction with ozone; the half-life for this reaction is about 23 hours. beta-Pinene does not contain chromophores that absorb at wavelengths >290 nm and therefore is not expected to be susceptible to direct photolysis by sunlight. If released to soil, beta-pinene is expected to have slight mobility based upon an estimated Koc of 4,400. Volatilization from moist soil surfaces is expected to be an important fate process based upon an estimated Henry's Law constant of 0.16 atm-cu m/mole. However, adsorption to soil is expected to attenuate volatilization. beta-Pinene may volatilize from dry soil surfaces based upon its vapor pressure. Biodegradation data were not available. However, by analogy to alpha-pinene which reached 95% of its theoretical BOD using activated sludge in the Japanese MITI test, biodegradation may be an important environmental fate process for beta-pinene. If released into water, beta-pinene is expected to adsorb to suspended solids and sediment based upon the estimated Koc. Volatilization from water surfaces is expected to be an important fate process based upon this compound's estimated Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 3 hours and 5 days, respectively. However, volatilization from water surfaces is expected to be attenuated by adsorption to suspended solids and sediment in the water column. The estimated volatilization half-life from a model pond is 340 days if adsorption is considered. An estimated BCF of 320 suggests the potential for bioconcentration in aquatic organisms is high, provided the compound is not metabolized by the organism. Hydrolysis is not expected to be an important environmental fate process since this compound lacks functional groups that hydrolyze under environmental conditions. Occupational exposure to beta-pinene may occur through inhalation and dermal contact with this compound at workplaces where beta-pinene is produced or used. Monitoring and use data indicate that the general population may be exposed to beta-pinene via inhalation of ambient air and dermal contact with this compound or other products containing beta-pinene. (SRC)

PEER REVIEWED

Probable Routes of Human Exposure:

Occupationally, workers should be protected from inhaling pinene vapors and from direct skin contact. /Pinene/

[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994., p. 1289] **PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 77,244 workers (13,763 of these were female) were potentially exposed to beta-pinene in the US(1). Occupational exposure to beta-pinene may occur through inhalation and dermal contact with this compound at workplaces where beta-pinene is produced or used(SRC). Monitoring and use data indicate that the general population may be exposed to beta-pinene via inhalation of ambient air and dermal contact with this compound or other products containing beta-pinene(SRC).

[(1) NIOSH; NOES. National Occupational Exposure Survey conducted from

1981-1983. Estimated numbers of employees potentially exposed to specific agents by 2-digit standard industrial classification (SIC). Available at <http://www.cdc.gov/noes/> as of Sept 25, 2008.] **PEER REVIEWED**

beta-Pinene median concentration levels for children who attended two inner-city schools in Minneapolis, MN were reported as 0.1, 0.1 and 2.5 ug/cu m outdoors, indoors at school and indoors at home, respectively, during winter, 2000; levels for spring 2000 were 0.1, 0.1 and 1.5 ug/cu m, respectively(1). Pinene concentration, both alpha- and beta- combined, ranged from not detected (2 mg/cu m) to 193 mg/cu m in workplace air from a thermomechanical pulp production plant(2). beta-Pinene workroom air level in Swedish saw sheds of sawmills processing Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) were reported at 6.3% relative to total terpene concentration during sawing of Scot's pine(3). Danish workers picking up household waste are susceptible because garden waste carried by garbage trucks emits beta-pinene into the surrounding air(4).

[(1) Adgate JL et al; Environ Health Perspect 112: 1386-92 (2004) (2) Goyer N; Appl Occup Environ Hyg 9: 428-32 (1994) (3) Svedberg U, Galle B; Appl Occup Environ Hyg 15: 686-94 (2000) (4) Wilkins K, Larsen K; Chemosphere 32: 2049-55 (1996)] **PEER REVIEWED**

Average Daily Intake:

Consumption: Annual 7833.33 lbs; Individual: 0.006638 mg/kg/day

[Burdock, G.A. (ed.). Fenaroli's Handbook of Flavor Ingredients. 5th ed. Boca Raton, FL 2005, p. 1586] **PEER REVIEWED**

Natural Pollution Sources:

THE ESSENTIAL OIL OF A SARDINIAN SAMPLE OF MYRTUS COMMUNIS WAS EXAMINED BY GAS-LIQUID CHROMATOGRAPHY-MASS SPECTROMETRY (GLC-MS); 22 PEAKS WERE SEPARATED, FOR WHICH THE MASS SPECTRA ARE SHOWN, TOGETHER WITH THE RETENTION TIMES, THE AREAS OF THE PEAKS, & PERCENTAGE COMPOSITION. THE TERPENE CONTENT WAS VERY HIGH; ALPHA-PINENE & BETA-PINENE CONSTITUTED 52.43% & 0.68%, RESPECTIVELY, OF THE OIL.

[TATEO F, PICCI V; GLC-MS CHARACTERIZATION OF ESSENTIAL OIL OF MYRTUS COMMUNIS L FROM SARDINIA; RIV SOC ITAL SCI ALIMENT 11(1) 53 (1982)] **PEER REVIEWED**

USUALLY OCCURRING TOGETHER WITH ALPHA-PINENE BUT IN SMALLER AMT. THE D- & L-FORMS ARE REPORTED FOUND IN THE ESSENTIAL OILS OF VARIOUS ARTEMISIAE & SEVERAL CUPRESSACEAE, IN CORIANDER & CUMIN. THE L-FORM IS A CONSTITUENT OF SEVERAL CITRUS OILS.

[Fenaroli's Handbook of Flavor Ingredients. Volume 2. Edited, translated, and revised by T.E. Furia and N. Bellanca. 2nd ed. Cleveland: The Chemical Rubber Co., 1975., p. 486] **PEER REVIEWED**

THE MONOTERPENE HYDROCARBON FRACTION REPRESENTING 70.4% OF

PINUS PUMILIO OIL WAS REPORTED...TO CONTAIN D-LIMONENE (42.1%), ALPHA-PINENE (18.4%), DELTA-CARENE (11.5%), BETA-PINENE (8.1%), BETA-PHELLANDRENE (8.0%), CAMPHENE (4.3%), MYRCENE (3.6%) & SMALLER AMT OF ALPHA-, & GAMMA-TERPINENE, P-CYMENE, TERPINOLENE & ALPHA-PHELLANDRENE.

[Opdyke, D.L.J. (ed.). Monographs on Fragrance Raw Materials. New York: Pergamon Press, 1979., p. 650] **PEER REVIEWED**

THE MONOTERPENE HYDROCARBON FRACTION REPRESENTING 68.9% OF PINUS SYLVESTRIS OIL WAS REPORTED...TO CONTAIN ALPHA-PINENE (65.8%), DELTA-CARENE (11.1%), BETA-PINENE (9.5%), D-LIMONENE (4.1%), MYRCENE (3.6%), CAMPHENE (2.9%), BETA-PHELLANDRENE (1.2%) & SMALLER AMT OF TERPINOLENE, OCIMENE, SABINENE & GAMMA-TERPINENE.

[Opdyke, D.L.J. (ed.). Monographs on Fragrance Raw Materials. New York: Pergamon Press, 1979., p. 652] **PEER REVIEWED**

beta-Pinene is a natural hydrocarbon emission product from softwood and some hardwood trees(SRC), in particular spruce species, *Pinus glauca*, *P. abies* and *P. pungens*(1), and eucalyptus species *Eucalyptus dunnii*, *E. salgina* and *E. citriodora*(2). The Mediterranean oak species *Quercus ilex* L. emits monoterpenes of which 22.92% is beta-pinene(3).

[(1) Kempf K et al; Atmos Environ 30: 1381-9 (1996) (2) Zini CA et al; J Agric Food Chem 50: 7199-205 (2002) (3) Kesselmeier J et al; Atmos Environ 30: 1841-50 (1996)] **PEER REVIEWED**

Artificial Pollution Sources:

beta-Pinene's production and use as an intermediate for perfumes and flavorings, in polyterpene resins(1), and as a fragrance ingredient(2) may result in its release to the environment through various waste streams(SRC).

[(1) Lewis RJ Sr, ed; Hawley's Condensed Chemical Dictionary. 14th ed. NY, NY: John Wiley and Sons, p. 880 (2001) (2) Ashford RD; Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd. pg. 717 (1994)] **PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of 4,400(SRC), determined from a log Kow of 4.16(2) and a regression-derived equation(3), indicates that beta-pinene is expected to have slight mobility in soil(SRC). Volatilization of beta-pinene from moist soil surfaces is expected to be an important fate process(SRC) given an estimated Henry's Law constant of 0.16 atm-cu m/mole(SRC), using a fragment constant estimation method(4). However, adsorption to soil is expected to attenuate volatilization(SRC). beta-Pinene is expected to volatilize from dry soil surfaces(SRC) based upon a vapor pressure of 2.93 mm Hg(5). Biodegradation data were not available(SRC, 2008). However, by analogy to alpha-pinene which reached 95% of its theoretical BOD using activated sludge in the Japanese MITI test(6), biodegradation may

be an important environmental fate process for beta-pinene in soil(SRC).

[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Griffin S et al; J Chromatog A 864: 221-8 (1999) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9 (1990) (4) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (5) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, DC: Taylor and Francis (1989) (6) Chemical Risk Information Platform (CHRIP). Biodegradation and Bioconcentration. Ver 2006.01.30 Updated. National Institute of Technology and Evaluation. Tokyo, Japan. alpha-Pinene (80-56-8). Available from the database query page at http://www.safe.nite.go.jp/english/kizon/KIZON_start_hazkizon.html as of Sept 9, 2008.] **PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 4,400(SRC), determined from a log Kow of 4.16(2) and a regression-derived equation(3), indicates that beta-pinene is expected to adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is expected(3) based upon an estimated Henry's Law constant of 0.16 atm-cu m/mole(SRC), developed using a fragment constant estimation method(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 3 hours and 5 days, respectively(SRC). However, volatilization from water surfaces is expected to be attenuated by adsorption to suspended solids and sediment in the water column. The estimated volatilization half-life from a model pond is 340 days if adsorption is considered(5). According to a classification scheme(6), an estimated BCF of 320(SRC), from its log Kow(2) and a regression-derived equation(7), suggests the potential for bioconcentration in aquatic organisms is high, provided the compound is not metabolized by the organism(SRC). beta-Pinene is not expected to undergo hydrolysis in the environment due to the lack of functional groups that hydrolyze under environmental conditions(3). Biodegradation data were not available(SRC, 2008). However, by analogy to alpha-pinene which reached 95% of its theoretical BOD using activated sludge in the Japanese MITI test(8), biodegradation may be an important environmental fate process for beta-pinene in water(SRC).

[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Griffin S et al; J Chromatog A 864: 221-8 (1999) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 7-4, 7-5, 15-1 to 15-29 (1990) (4) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (5) US EPA; EXAMS II Computer Simulation (1987) (6) Franke C et al; Chemosphere 29: 1501-14 (1994) (7) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (8) Chemical Risk Information Platform (CHRIP). Biodegradation and Bioconcentration. Ver 2006.01.30 Updated. National Institute of Technology and Evaluation. Tokyo, Japan. alpha-Pinene (80-56-8). Available from the database query page at http://www.safe.nite.go.jp/english/kizon/KIZON_start_hazkizon.html as of Sept 9, 2008.] **PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), beta-pinene, which has a vapor pressure of 2.93 mm Hg at 25 deg C(2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase beta-pinene is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in

air is estimated to be 4.9 hours(SRC), calculated from its rate constant of 7.89×10^{-11} cu cm/molecule-sec at 25 deg C(3). The rate constant for the vapor-phase reaction of beta-pinene with ozone has been estimated as 1.2×10^{-17} cu cm/molecule-sec at 25 deg C(SRC) that was derived using a structure estimation method(3). This corresponds to an atmospheric half-life of about 23 hours at an atmospheric concentration of $7 \times 10^{+11}$ ozone molecules per cu cm(4). beta-Pinene does not contain chromophores that absorb at wavelengths >290 nm(5) and therefore is not expected to be susceptible to direct photolysis by sunlight(SRC).

[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, DC: Taylor and Francis (1989) (3) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993) (4) Atkinson R, Carter WPL; Chem Rev 84: 437-70 (1984) (5) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 8-12 (1990)] **PEER REVIEWED**

Environmental Biodegradation:

Pinene is degraded by microbiological organisms in soil. /Pinene/

[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994., p. 1289] **PEER REVIEWED**

AEROBIC: Biodegradation data on beta-pinene were not available(SRC, 2008). However, by analogy to alpha-pinene which reached 95% of its theoretical BOD using activated sludge in the Japanese MITI test(1), biodegradation may be an important environmental fate process for beta-pinene(SRC). Forest soil extracts and enriched cultures used as inocula for testing biodegradation of monoterpenes and alpha-pinene were found to readily degrade this class of chemical(1). Another study tested biodegradation of monoterpenes and alpha-pinene in liquid and soil-slurry systems and found alpha-pinene to degrade at 5.2 mg/L-hr(2).

[(1) Chemical Risk Information Platform (CHRIP). Biodegradation and Bioconcentration. Ver 2006.01.30 Updated. National Institute of Technology and Evaluation. Tokyo, Japan. alpha-Pinene (80-56-8). Available from the database query page at http://www.safe.nite.go.jp/english/kizon/KIZON_start_hazkizon.html as of Sept 9, 2008. (2) Misra G et al; Appl Microbiol Biotechnol 45: 831-8 (1996) (3) Misra G, Pavlostathis SG; Appl Microbiol Biotechnol 47: 572-7 (1997)] **PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of beta-pinene with photochemically-produced hydroxyl radicals is 7.89×10^{-11} cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 4.9 hours at an atmospheric concentration of $5 \times 10^{+5}$ hydroxyl radicals per cu cm(1). The reaction of OH and beta-pinene results in the formation of formaldehyde and acetone(2). The rate constant for the vapor-phase reaction of beta-pinene with ozone has been estimated as 1.2×10^{-17} cu cm/molecule-sec at 25 deg C(SRC) that was derived using a structure estimation

method(3). This corresponds to an atmospheric half-life of about 23 hours at an atmospheric concentration of 7×10^{11} ozone molecules per cu cm(4). The main products from the reaction of ozone and gas-phase beta-pinene were identified as nopinone, HCHO; 3-hydroxynopinone, HCOOH and cis-pinic acid are also produced(5). beta-Pinene is not expected to undergo hydrolysis in the environment due to the lack of functional groups that hydrolyze under environmental conditions(6). beta-Pinene does not contain chromophores that absorb at wavelengths >290 nm(6) and therefore is not expected to be susceptible to direct photolysis by sunlight(SRC).

[(1) Atkinson R; J Phys Chem Ref. Monograph No. 1 (1989) (2) Grosjean D et al; Environ Sci Technol 26: 1526-33 (1992) (3) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993) (4) Atkinson R, Carter WPL; Chem Rev 84: 437-70 (1984) (5) Winterhalter R et al; J Atmos Chem 35: 165-97 (2000) (6) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7-4, 7-5, 8-12 (1990)] **PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 320 was calculated in fish for beta-pinene(SRC), using a log Kow of 4.16(1) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is high(SRC), provided the compound is not metabolized by the organism(SRC).

[(1) Griffin S et al; J Chromatog A 864: 221-8 (1999) (2) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (3) Franke C et al; Chemosphere 29: 1501-14 (1994)] **PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc of beta-pinene is estimated as 4,400(SRC), using a log Kow of 4.16(1) and a regression-derived equation(2). According to a classification scheme(3), this estimated Koc value suggests that beta-pinene is expected to have slight mobility in soil.

[The Koc of beta-pinene is estimated as 4,400(SRC), using a log Kow of 4.16(1) and a regression-derived equation(2). According to a classification scheme(3), this estimated Koc value suggests that beta-pinene is expected to have slight mobility in soil.] **PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for beta-pinene is estimated as 0.16 atm-cu m/mole(SRC) using a fragment constant estimation method(1). This Henry's Law constant indicates that beta-pinene is expected to volatilize rapidly from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 3 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 5 days(SRC). beta-Pinene's Henry's Law constant indicates that volatilization from moist soil surfaces may occur(SRC). However, volatilization from water surfaces is expected to be attenuated by adsorption to suspended solids and sediment in the water column. The volatilization half-life from a model pond is about 340 days when adsorption is considered(3). beta-Pinene is expected to volatilize from dry soil

surfaces(SRC) based upon a vapor pressure of 2.93 mm Hg(4).

[(1) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) US EPA; EXAMS II Computer Simulation (1987) (4) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, DC: Taylor and Francis (1989)] **PEER REVIEWED**

Environmental Water Concentrations:

SURFACE WATER: beta-Pinene was detected in the Wolfegger, Ach and Schussen rivers in Southwest Germany, considered weakly polluted small rivers and brooks(1). GC-MS analysis of water from the Black Warrior River in Tuscaloosa, AL revealed the presence of beta-pinene(2).

[(1) Juettner F; Wat Sci Tech 25: 155-64 (1992) (2) Bertsch W, Anderson E; J Chromatography 112: 701-18 (1975)] **PEER REVIEWED**

RAIN/SNOW/FOG: beta-Pinene was not detected in snow samples collected in early March from Neulanieme (Kuopio, Central-Eastern Finland); Nellim (Lapland, Finland); Muonio (Lapland, Finland); Levi (Lapland, Finland); Moscow State University (clean area, Moscow, Russia); Moscow region - summer cottage area; Shuch'e (Volga River, Russia); Baikal'sk on Lake Baikal (near pulp/paper mill, Siberia(1). The compound was detected in samples from Butovo (clean area, southern Moscow, Russia) at 0.04 ug/kg(1).

[(1) Poliakova OV et al; Toxicol Environ Chem 75: 181-94 (2000)] **PEER REVIEWED**

Effluent Concentrations:

An emission source profile was constructed based on data obtained from the Cassiar tunnel of Cairo, Egypt which revealed a 0.49% by weight concentration of beta-pinene in roadway emissions and 0.30% by weight in motorcycle emissions(1). Emissions of 0.36 and 0.77% by weight beta-pinene were obtained from regular and high grade whole gasoline emissions, respectively(1). The compound was detected, not quantified in emissions from a composting facility in Joyceville, Ontario, Canada(2). beta-Pinene emissions from the Fresh Kills Landfill in Staten Island, NY ranged from 0.2-0.7%(3).

[(1) Doskey PV et al; J Air and Waste Manage Assoc 49: 814-22 (1999) (2) Krzymien M et al; J Air Waste Manage Assoc 49: 804-13 (1999) (3) Eklund B et al; Environ Sci Technol 32: 2233-37 (1998)] **PEER REVIEWED**

beta-Pinene has been identified as a volatile organic ingredient of wood-based furniture with its possible source being an ecological coating system based on natural resins, nitrocellulose, and/or softwood construction(1). Building materials when humidified can support microbial growth of mold fungi, bacteria, actinomycetes and basidiomycetes which can produce metabolites such as beta-pinene(2).

[(1) Salthammer T; pp. 203-18 in Organic Indoor Air Pollutants. Salthammer T, ed., New York, NY: Wiley-VCH (1999) (2) Bjurman J; pp. 259-74 in Organic Indoor Air Pollutants. Salthammer T, ed., New York, NY: Wiley-VCH (1999)] **PEER REVIEWED**

beta-Pinene was identified in emissions from food preparation sites in Mexico City(1). There are more than 30,000 registered places where food is cooked and more than 2,500 sidewalk meal vendors; there are no control mechanisms to reduce emissions from these sources. Sampling was conducted from March 20-31, 1998. beta-Pinene concentrations were 0.37, 0.04, 0.58, 0.28 and 0 ppb C% of total emissions from restaurants using charcoal grills, tortillerias, rotisseries, food frying places and restaurants using LP gas stoves, respectively(1). Mean concentrations of beta-pinene in residential wood combustion emissions using softwood and hardwood from Denver, CO were determined; emissions from a fireplace were 48.77 and 2.81 mg/kg, respectively; emission from a wood stove using hard wood was 15.37 mg/kg(2).

[(1) Mugica V et al; Atmos Environ 35: 1729-34 (2001) (2) McDonald JD et al; Environ Sci Technol 34: 2080-91 (2000)] **PEER REVIEWED**

Atmospheric Concentrations:

PLANT SPECIES RELEASE APPRECIABLE QUANTITIES OF VOLATILE ORGANIC SUBSTANCES TO THE ATMOSPHERE. THE MAJOR COMPD EMITTED ARE MONOTERPENES LIKE ALPHA-PINENE, BETA-PINENE, & LIMONENE & THE HEMITERPENE ISOPRENE.

[RASMUSSEN RA; WHAT DO THE HYDROCARBONS FROM TREES CONTRIBUTE TO AIR POLLUTION?; J AIR POLLUT CONTROL ASSOC 22(7) 537 (1972)] **PEER REVIEWED**

INDOOR: beta-Pinene in indoor air was detected in buildings 1 (first floor), 2 (fourth floor) and 3 (exhaust) at concentrations of 7.9, 5.5, and 3.3 ug/m cu, respectively(1). Geometric mean concentrations of beta-pinene in four manufactured and seven site-built homes located in Florida ranged from 1.5 to 10.6 ppb and 5.9 to 26.3 ppb, respectively(2).

[(1) Wescer CJ et al; Am Ind Hyg Assoc 51: 261-8 (1990) (2) Hodgson AT et al; Indoor Air 10: 178-92 (2000)] **PEER REVIEWED**

RURAL/REMOTE: The ambient air over the Borden Forest in Ontario, Canada during the leafless period was found to contain 0.01 ppbv beta-pinene(1). beta-Pinene concentrations from the forest ground and canopy in Whitaker's Forest, in the Sierra Nevada Mountains, California ranged from 0.47-2.0 and 1.1-6.8 ug/m-cu, respectively(2). GC-MS analysis of forest air from Eggegebirge, North Rhine-Westfalia, West Germany verified beta-pinene presence in the ambient air(3). Air samples from a Scots Pine forest located in Jadraas, Central Sweden contained measured beta-pinene concentrations in the range of 0.1-<0.5 ppbv(4). Average beta-pinene concentrations in ambient air from four sites in southern Taiwan sampled in December 1998 and May 1999 were: not reported, Shua-Hua; not reported, May-Nung; 4 ug/cu m, Ping-Ting; and not reported, Chao-Chou(5).

[(1) Fuentes JD et al; J atmos Chem 25: 67-95 (1996) (2) Helmig D, Arey J; Sci Total Environ 112: 233-50 (1992) (3) Helmig D et al; Chemos 19: 1399-1412 (1989) (4) Janson R; J Atmos Chem 14: 385-94 (1992) (5) Hsieh C-C, Tsai J-H; Chemosphere 50: 545-56 (2003)] **PEER REVIEWED**

Food Survey Values:

beta-Pinene was detected in the aromas of 20 out of 26 and 19 out of 63 fresh wild mushrooms by dynamic headspace concentration and solvent extraction, respectively(1). A purge and trap gas chromatogram technique revealed a 0.0015 ppm beta-pinene concentration in fresh grapefruit juice(2). beta-Pinene was identified as one of the flavor compounds in tea derived from fresh pine sprouts or pine needles harvested from Korean red pine trees (*Pinus densiflora* Sieb. Et Zucc.) in May-June 1995(3). The compound was identified as a volatile odor compound from 30%, 12% and 5% of total emissions from fat frankfurters at mean concentrations of 3,330, 3,570 and 5,060 relative peak areas (1 ng of bromobenzene = 100), respectively(4).

[(1) Breheret S et al; J Agric Food Chem 45: 831-6 (1997) (2) Cadwallader KR, Xu Y; J Agric Food Chem 42: 782-4 (1994) (3) Kim KY, Chung HJ; J Agric Food Chem 48: 1269-72 (2000) (4) Chevanne FFV, Farmer LJ; J Agric Food Chem 47: 5161-8 (1999)] **PEER REVIEWED**

Plant Concentrations:

beta-Pinene emissions from Loblolly Pine, Shortleaf Pine, Sweet Gum, Elm, Cypress, Maple and Red oak located in the forested areas near Baton Rouge, LA were 2600, 5400, 1400-3300, 510, 380, 4500, and 20 ug/kg-foliage/hr, respectively(1). Hydrocarbon emission rates for beta-pinene from 3 spruce species, *Picea glauca*, *P. abies*, and *P. pungens*, at 30 deg C were 0.19, 0.43 and 0.12 ug C/g-hr, respectively, at 1000 umol-sq m/sec photosynthetically active radiation(2). The Mediterranean oak species *Quercus ilex* L. emits monoterpenes of which 22.92% is beta-pinene(3). Levels above a Japanese red pine (*Pinus densiflora*) forest at Oshiba plateau, Nagano Prefecture, Japan were measured from May to November 2000; maximum monthly concentrations reported were 50, 100, 60, 20 and 92 parts per trillion volume in May, June, August, September and October, respectively(4). beta-Pinene exhibited seasonal emission variations in Australian *Eucalyptus globulus* trees sampled under natural growing conditions from June 1996 to May 1997. Monthly average relative proportions were beginning with May and sampled for the following 11 months were: 83; 79; 95; 83; 80; 98; 74; 81; 82; 78; 67; 81%(5). Sampling was conducted in the Scandanavian boreal zone in Asa Research Park, Sweden and Mekrijarvi Research Station, Finland in the spring and summer of 1997; relative percent composition for beta-pinene from Scots pine at Asa and Mekrijarvi were 2 and 4%, respectively(6). beta-Pinene was detected, not quantified in ambient air around *Pinus halepensis* trees located in Bab-Ezzouar, a suburb of Algiers(7). The compound was identified at a relative abundance of between 1 and 10% of total identified peaks in emissions from leaves of *Eucalyptus dunnii*, *Eucalyptus salgina* and *Eucalyptus citriodora*(8).

[(1) Khalil MAK, Rasmussen RA; J Air Waste Manage Assoc 42: 810-13 (1992) (2) Kempf K et al; Atmos Environ 30: 1381-9 (1996) (3) Kesselmeier J et al; Atmos Environ 30: 1841-50 (1996) (4) Tani A et al; Atmos Environ 36: 3391-402 (2002) (5) He C et al; Chemosphere - Global Change Sci 2: 65-76 (2000) (6) Janson R, Deserves C; Atmos Environ 35: 4629-37 (2001) (7) Yassaa N et al; Atmos Environ 34: 2809-16 (2000) (8) Zini CA et al; J Agric Food Chem 50: 7199-205 (2002)] **PEER REVIEWED**

Other Environmental Concentrations:

Household products containing beta-pinene include newspaper and floor wax pastes(1). The compound is one of the major monoterpenes found in pepper oil at 17% but is absent in pepper leaf oil(2). beta-Pinene has been detected, not quantified in some colognes and soaps(3).

[(1) Salthammer T; pp. 219-32 in Organic Indoor Air Pollutants. Salthammer T, ed., New York, NY: Wiley-VCH (1999) (2) Sumathikutty MA et al; Indian Perfumer 25: 15-9 (1981) (3) Cooper SD et al; J Expos Anal Environ Epid 5: 57-75 (1995)] **PEER REVIEWED**

Environmental Standards & Regulations:

FDA Requirements:

Beta-Pinene is a food additive permitted for direct addition to food for human consumption as a synthetic flavoring substance and adjuvant in accordance with the following conditions: a) they are used in the minimum quantity required to produce their intended effect, and otherwise in accordance with all the principles of good manufacturing practice, and 2) they consist of one or more of the following, used alone or in combination with flavoring substances and adjuvants generally recognized as safe in food, prior-sanctioned for such use, or regulated by an appropriate section in this part.

[21 CFR 172.515 (USFDA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 2, 2008: <http://www.gpoaccess.gov/ecfr> **PEER REVIEWED**

Allowable Tolerances:

Beta-Pinene is a food additive permitted for direct addition to food for human consumption as a synthetic flavoring substance and adjuvant in accordance with the following conditions: a) they are used in the minimum quantity required to produce their intended effect, and otherwise in accordance with all the principles of good manufacturing practice, and 2) they consist of one or more of the following, used alone or in combination with flavoring substances and adjuvants generally recognized as safe in food, prior-sanctioned for such use, or regulated by an appropriate section in this part.

[21 CFR 172.515 (USFDA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 2, 2008: <http://www.gpoaccess.gov/ecfr> **PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C₁₀H₁₆

PEER REVIEWED

Molecular Weight:

136.24

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 1283] **PEER REVIEWED**

Color/Form:

Colorless transparent liquid

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 995] **PEER REVIEWED**

Odor:

CHARACTERISTIC TURPENTINE ODOR; DRY, WOODY OR RESINOUS AROMA

[Fenaroli's Handbook of Flavor Ingredients. Volume 2. Edited, translated, and revised by T.E. Furia and N. Bellanca. 2nd ed. Cleveland: The Chemical Rubber Co., 1975., p. 486] **PEER REVIEWED**

PINEY, TURPENTINE-LIKE ODOR

[Furia, T.E. (ed.). CRC Handbook of Food Additives. 2nd ed. Volume 2. Boca Raton, Florida: CRC Press, Inc., 1980., p. 298] **PEER REVIEWED**

Terpene odor

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 995] **PEER REVIEWED**

Taste:

PINEY, TURPENTINE-LIKE TASTE

[Furia, T.E. (ed.). CRC Handbook of Food Additives. 2nd ed. Volume 2. Boca Raton, Florida: CRC Press, Inc., 1980., p. 298] **PEER REVIEWED**

Boiling Point:

166 deg C

[Lide, D.R. CRC Handbook of Chemistry and Physics 86TH Edition 2005-2006. CRC Press, Taylor & Francis, Boca Raton, FL 2005, p. 3-436] **PEER REVIEWED**

Melting Point:

-61.5 deg C

[Lide, D.R. CRC Handbook of Chemistry and Physics 86TH Edition 2005-2006. CRC Press, Taylor & Francis, Boca Raton, FL 2005, p. 3-436] **PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature: 643 K; Critical pressure: 2.76X10+6 Pa

[Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989.] **PEER REVIEWED**

Density/Specific Gravity:

0.860 at 25 deg C

[Lide, D.R. CRC Handbook of Chemistry and Physics 86TH Edition 2005-2006. CRC Press, Taylor & Francis, Boca Raton, FL 2005, p. 3-436]
PEER REVIEWED

Heat of Combustion:

43,013.3 KJ/kg = 18,495.7 BTU/lb at 25 deg C

[Yaws, C.L., Chemical Properties Handbook: Physical, Thermodynamic, Environmental, Transport, Safety and Health Related Properties for Organic and Inorganic Chemicals. McGraw-Hill, New York, NY 1999., p. 597] **PEER REVIEWED**

Heat of Vaporization:

5.0X10+7 J/kmol at 211.61 K

[Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989.] **PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow = 4.16

[Griffin S et al; J Chromatog A 864: 221-8 (1999)] **PEER REVIEWED**

Solubilities:

ALMOST INSOL IN PROPYLENE GLYCOL

[Fenaroli's Handbook of Flavor Ingredients. Volume 2. Edited, translated, and revised by T.E. Furia and N. Bellanca. 2nd ed. Cleveland: The Chemical Rubber Co., 1975., p. 486] **PEER REVIEWED**

Soluble in benzene, ethanol and ethyl ether

[Lide, D.R. CRC Handbook of Chemistry and Physics 86TH Edition 2005-2006. CRC Press, Taylor & Francis, Boca Raton, FL 2005, p. 3-436]
PEER REVIEWED

Soluble in alcohol and chloroform

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 1283] **PEER REVIEWED**

In water, 4.89 mg/L at 25 deg C (est)

[US EPA; Estimation Program Interface (EPI) Suite. Ver.3.12. Nov 30,

2004. Available from, as of Sept 24, 2008:

<http://www.epa.gov/oppt/exposure/pubs/episuited1.htm> **PEER REVIEWED**

Spectral Properties:

Index of refraction: 1.4768 at 25 deg C

[Lide, D.R. CRC Handbook of Chemistry and Physics 86TH Edition 2005-2006. CRC Press, Taylor & Francis, Boca Raton, FL 2005, p. 3-436]

PEER REVIEWED

Surface Tension:

26.85 dynes/cm at 25 deg C

[Yaws, C.L., Chemical Properties Handbook: Physical, Thermodynamic, Environmental, Transport, Safety and Health Related Properties for Organic and Inorganic Chemicals. McGraw-Hill, New York, NY 1999., p. 228] **PEER REVIEWED**

Vapor Density:

4.7 (Air = 1)

[Sell CS; Kirk-Othmer Encyclopedia of Chemical Technology. (2001). NY, NY: John Wiley & Sons; Terpenoids. Online Posting Date: Sept 15, 2006.]

PEER REVIEWED

Vapor Pressure:

2.93 mm Hg at 25 deg C

[Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989.] **PEER REVIEWED**

Viscosity:

1.522 cP at 25 deg C

[Yaws, C.L., Chemical Properties Handbook: Physical, Thermodynamic, Environmental, Transport, Safety and Health Related Properties for Organic and Inorganic Chemicals. McGraw-Hill, New York, NY 1999., p. 494] **PEER REVIEWED**

Other Chemical/Physical Properties:

Optically active and racemic beta-pinenes are present in turpentine oils

[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed. Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present., p. VA2: 167 (1985)] **PEER REVIEWED**

BP: 164-166 deg C at 760 mm Hg; Density: 0.8654 at 20 deg C/20 deg C; Index of refraction: 1.4739 at 20 deg C /d-form/

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc.,

2006..., p. 1283] **PEER REVIEWED**

SPECIFIC OPTICAL ROTATION: +28.6 DEG/D; BP: 164-166 DEG C at 760 MM HG; DENSITY: 0.8654 at 20 DEG C/4 DEG C; MAX ABSORPTION (ALC): 208 NM (LOG E= 3.72); INDEX OF REFRACTION: 1.4789 at 20 DEG C; SADTLER REF NUMBER: 2188 (IR, PRISM); 274 (NMR, VARIAN) /D-FORM/

[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979., p. c-440] **PEER REVIEWED**

IR: 4987 (Coblentz Society Spectral Collection) /d-form/

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V2: 1641] **PEER REVIEWED**

1H NMR: 274 (Varian Associates NMR Spectra Catalogue) /d-form/

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V2: 1641] **PEER REVIEWED**

MASS: 36723 (NIST/EPA/MSDC Mass Spectral Database, 1990 version); 706 (Atlas of Mass Spectral Data, John Wiley & Sons, New York) /d-form/

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V2: 1641] **PEER REVIEWED**

UV: HBCP /d-form/

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V2: 1641] **PEER REVIEWED**

BP: 165-166 deg C at 760 mm Hg /dl-form/

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006..., p. 1283] **PEER REVIEWED**

INSOL IN WATER; SOL IN ALC, ETHER, BENZENE, & OTHER SOLVENTS; VERY SOL IN CHLOROFORM /D- & L-ISOMER/

[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979., p. C-440] **PEER REVIEWED**

SPECIFIC OPTICAL ROTATION: -21.5 DEG at 25 DEG C/D; MAX ABSORPTION (ALC): 208 NM (LOG E= 3.72); BP: 164 DEG C at 760 MM HG; DENSITY: 0.8694 at 20 DEG C/4 DEG C; INDEX OF REFRACTION: 1.4762 at 20 DEG C /L-FORM/

[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979., p. C-440] **PEER REVIEWED**

IR: 4987 (Coblentz Society Spectral Collection) /l-form/

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V2: 1641] **PEER REVIEWED**

¹H NMR: 274 (Varian Associates NMR Spectra Catalogue) /l-form/

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V2: 1641] **PEER REVIEWED**

MASS: 706 (Atlas of Mass Spectral Data, John Wiley & Sons, New York) /l-form/

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V2: 1641] **PEER REVIEWED**

UV: 3-268 (Phillip et al., Organic Electronic Spectral Data. John Wiley & Sons, New York)

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V2L 1641] **PEER REVIEWED**

BP: 162-163 deg C at 760 mm Hg; Density: 0.874 at 15 deg C; Index of refraction: 1.4872 at 15 deg C /l-form/

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 1283] **PEER REVIEWED**

Henry's Law constant = 0.16 atm-cu m/mole at 25 deg C (est)

[US EPA; Estimation Program Interface (EPI) Suite. Ver.3.12. Nov 30, 2004. Available from, as of Sept 24, 2008:
<http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm> **PEER REVIEWED**

Hydroxyl radical reaction rate constant = 7.89X10⁻¹¹ cu cm/molecule-sec at 25 deg C

[Atkinson R; J Phys Chem Ref. Monograph No. 1 (1989)] **PEER REVIEWED**

Chemical Safety & Handling:

DOT Emergency Guidelines:

/GUIDE 128: FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE)/ Fire or Explosion: HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks). Vapor explosion hazard indoors, outdoors or in sewers. Those substances designated with a "P" may polymerize explosively when heated or involved in a fire. Runoff to sewer may create fire or explosion hazard. Containers may explode when heated. Many liquids are lighter than water. Substances may be transported hot. /alpha-Pinene/

[U.S. Department of Transportation. 2004 Emergency Response Guidebook. A Guide book for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident. Washington, D.C. 2004] **PEER REVIEWED**

/GUIDE 128: FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE)/

Health: Inhalation or contact with material may irritate or burn skin and eyes. Fire may produce irritating, corrosive and/or toxic gases. Vapors may cause dizziness or suffocation. Runoff from fire control or dilution water may cause pollution. /alpha-Pinene/

[U.S. Department of Transportation. 2004 Emergency Response Guidebook. A Guide book for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident. Washington, D.C. 2004]
PEER REVIEWED

/GUIDE 128: FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE)/
Public Safety: CALL Emergency Response Telephone Number As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. Ventilate closed spaces before entering. /alpha-Pinene/

[U.S. Department of Transportation. 2004 Emergency Response Guidebook. A Guide book for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident. Washington, D.C. 2004]
PEER REVIEWED

/GUIDE 128: FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE)/
Protective Clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters' protective clothing will only provide limited protection. /alpha-Pinene/

[U.S. Department of Transportation. 2004 Emergency Response Guidebook. A Guide book for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident. Washington, D.C. 2004]
PEER REVIEWED

/GUIDE 128: FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE)/
Evacuation: Large spill: Consider initial downwind evacuation for at least 300 meters (1000 feet). **Fire:** If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. /alpha-Pinene/

[U.S. Department of Transportation. 2004 Emergency Response Guidebook. A Guide book for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident. Washington, D.C. 2004]
PEER REVIEWED

/GUIDE 128: FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE)/ **Fire:**
Caution: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient. **CAUTION:** For mixture containing a high percentage of an alcohol or polar solvent, alcohol-resistant foam may be more effective. **Small fires:** Dry chemical, CO₂, water spray or regular foam. **Large fires:** Water spray, fog or regular foam. Use water spray or fog; do not use straight streams. Move containers from fire area if you can do it without risk. **Fire involving tanks or car/trailer loads:** Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. **ALWAYS** stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or

monitor nozzles; if this is impossible, withdraw from area and let fire burn. /alpha-Pinene/

[U.S. Department of Transportation. 2004 Emergency Response Guidebook. A Guide book for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident. Washington, D.C. 2004]
PEER REVIEWED

/GUIDE 128: FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE)/ Spill or Leak: ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Use clean non-sparking tools to collect absorbed material. Large spills: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor; but may not prevent ignition in closed spaces. /alpha-Pinene/

[U.S. Department of Transportation. 2004 Emergency Response Guidebook. A Guide book for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident. Washington, D.C. 2004]
PEER REVIEWED

/GUIDE 128: FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE)/ First Aid: Move victim to fresh air. Call 911 or emergency medical service. Give artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. Wash skin with soap and water. Keep victim warm and quiet. In case of burns, immediately cool affected skin for as long as possible with cold water. Do not remove clothing if adhering to skin. Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves. /alpha-Pinene/

[U.S. Department of Transportation. 2004 Emergency Response Guidebook. A Guide book for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Incident. Washington, D.C. 2004]
PEER REVIEWED

Skin, Eye and Respiratory Irritations:

Irritating to eyes, respiratory system and skin... /(-)-Beta-pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]
PEER REVIEWED

...Irritant to skin and mucous membranes

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3243] **PEER REVIEWED**

Flash Point:

Flash point : 88 deg F

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial

Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc.
Hoboken, NJ. 2004., p. 3098] **PEER REVIEWED**

Fire Fighting Procedures:

EXTINGUISHING MEDIA. Suitable: For small (incipient) fires, use media such as "alcohol" foam, dry chemical, or carbon dioxide. For large fires, apply water from as far as possible. Use very large quantities (flooding) of water applied as a mist or spray; solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water. /(-)-Beta-pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]
PEER REVIEWED

FIREFIGHTING. Protective Equipment: Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes. Specific Hazard(s): Flammable liquid. Emits toxic fumes under fire conditions. Specific Method(s) of Fire Fighting: Use water spray to cool fire-exposed containers. /(-)-Beta-pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]
PEER REVIEWED

If material on fire or involved in fire: If material on fire or involved in fire: Do not extinguish fire unless flow can be stopped or safely confined. Use water in flooding quantities as fog. Solid streams of water may spread fire. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use foam, dry chemical, or carbon dioxide. /Pinene/

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 725] **PEER REVIEWED**

Hazardous Decomposition:

When heated to decomposition it emits acrid smoke and irritating fumes.

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 3099] **PEER REVIEWED**

Protective Equipment & Clothing:

PERSONAL PROTECTIVE EQUIPMENT Respiratory: Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU). Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Hand: Compatible chemical-resistant gloves. Eye: Chemical safety goggles. /(-)-Beta pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]
PEER REVIEWED

ENGINEERING CONTROLS. Safety shower and eye bath. Use nonsparking tools.

Mechanical exhaust required.

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]

****PEER REVIEWED****

Preventive Measures:

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.

****PEER REVIEWED****

Do not breathe vapor. Avoid contact with eyes, skin, and clothing. Avoid prolonged or repeated exposure. /(-)-Beta pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]

****PEER REVIEWED****

Wash thoroughly after handling. Wash contaminated clothing before reuse. /(-)-Beta pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]

****PEER REVIEWED****

If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without undue personnel hazard. Use water spray to knock-down vapors. /Pinene/

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 725] ****PEER REVIEWED****

Personnel protection: Avoid breathing vapors. Keep upwind. ... Do not handle broken packages unless wearing appropriate personal protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water. /Pinene/

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 725-6] ****PEER REVIEWED****

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions or dispersion of regulated contaminants in the work area. Ventilation control of the contaminant as close to its point of generation is both the most economical and safest method to minimize personnel exposure to airborne contaminants.

****PEER REVIEWED****

SRP: Contaminated protective clothing should be segregated in such a manner so that

there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.

PEER REVIEWED

Storage Conditions:

Keep container closed. Keep away from heat, sparks, and open flame. /(-)-Beta pinene/ [Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]

PEER REVIEWED

Cleanup Methods:

Accidental Release. METHODS FOR CLEANING UP. Cover with dry-lime, sand, or soda ash. Place in covered containers using non-sparking tools and transport outdoors. /(-)-Beta pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]

PEER REVIEWED

Disposal Methods:

SRP: The most favorable course of action is to use an alternative chemical product with less inherent propensity for occupational exposure or environmental contamination.

Recycle any unused portion of the material for its approved use or return it to the manufacturer or supplier. Ultimate disposal of the chemical must consider: the material's impact on air quality; potential migration in soil or water; effects on animal, aquatic, and plant life; and conformance with environmental and public health regulations.

PEER REVIEWED

Contact a licensed professional waste disposal service to dispose of this material. Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Observe all federal, state, and local environmental regulations. /(-)-Beta pinene/

[Sigma-Aldrich; MSDS for (-)-beta-pinene. 6 pp. (January 29, 2006)]

PEER REVIEWED

Occupational Exposure Standards:

Threshold Limit Values:

8 hr Time Weighted Avg (TWA): 20 ppm

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH, 2008, p. 59]

PEER REVIEWED

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a work day, and under no circumstances should they exceed 5 times the TLV-TWA, provided that the TLV-TWA is not exceeded.

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH, 2008, p. 5]
PEER REVIEWED

Manufacturing/Use Information:

Major Uses:

MONOMER FOR TERPENE RESINS-EG, FOR HOT MELT ADHESIVES

[SRI] **PEER REVIEWED**

CHEM INT FOR FRAGRANCES, EG, MYCENE, GERANIOL & LINALOOL

[SRI] **PEER REVIEWED**

FLAVORING AGENT FOR ICE CREAM & ICES, CANDY & BAKED GOODS

[SRI] **PEER REVIEWED**

Polyterpene resins, substitute for alpha pinene, intermediate for perfumes and flavorings.

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 995] **PEER REVIEWED**

Fragrance ingredient

[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994., p. 717] **PEER REVIEWED**

Pyrolytic cleavage of beta-pinene to myrcene, the starting material for acyclic terpenes, is used on an industrial scale.

[Ullmann's Encyclopedia of Industrial Chemistry. 6th ed.Vol 1: Federal Republic of Germany: Wiley-VCH Verlag GmbH & Co. 2003 to Present, p. V14 100 (2003)] **PEER REVIEWED**

Reported uses (ppm): (Flavor and Extract Manufacturers' Association , 2005)

Reported uses (ppm): (FEMA, 2005)

Food Category	Usual	Max.
Alcoholic beverages	9.64	15.52
Baked goods	26.12	98.16
Chewing gum	17.24	23.31
Condiments, relishes	20.00	40.00

Frozen dairy	20.12	49.73
Gelatins, puddings	9.77	14.88
Hard candy	14.90	76.54
Meat products	8.81	17.63
Nonalcoholic beverages	11.24	21.21
Soft candy	20.34	74.43

[Burdock, G.A. (ed.). Fenaroli's Handbook of Flavor Ingredients. 5th ed. Boca Raton, FL 2005, p. 1586] **PEER REVIEWED**

Manufacturers:

Arizona Chemical, 4600 Touchton Road East, Suite 500, Jacksonville, FL 32246 (904) 928-8700; Production site: Panama City, FL 32402

[SRI Consulting. 2008 Directory of Chemical Producers United States. Menlo Park, CA 2008, p. 607] **PEER REVIEWED**

Hercules Inc., Hercules Plaza, 1313 North Market Street, Wilmington, DE 19894, (302) 594-5000; Flavor and Fragrance Chemicals, Production sites: Brunswick, GA 31521; Hattiesburg, MS 39401

[SRI Consulting. 2008 Directory of Chemical Producers United States. Menlo Park, CA 2008, p. 607] **PEER REVIEWED**

International Flavors and Fragrances, Inc., 521 West 57th Street, New York, NY 10019 (212) 765-5500; Production site: Jacksonville, FL 32254

[SRI Consulting. 2008 Directory of Chemical Producers United States. Menlo Park, CA 2008, p. 607] **PEER REVIEWED**

Millennium Specialty Chemicals, Inc., P.O. Box 389, Jacksonville, FL 32201, (904) 768-5800; Production site: Jacksonville, FL 32201

[SRI Consulting. 2008 Directory of Chemical Producers United States. Menlo Park, CA 2008, p. 607] **PEER REVIEWED**

Penta Manufacturing Co., 50 Okner Parkway, Livingston, NJ 07034 (973)740-2300; Production site: East Hanover, NJ 07936

[SRI Consulting. 2008 Directory of Chemical Producers United States. Menlo Park, CA 2008, p. 607] **PEER REVIEWED**

Sigma-Aldrich Chemical Co., Inc, 3050 Spruce Street, St. Louis, MO 63103, (314) 534-4900; Production site: Not specified

[SRI Consulting. 2008 Directory of Chemical Producers United States. Menlo Park, CA 2008, p. 607] **PEER REVIEWED**

Methods of Manufacturing:

Isolated from American terpentine; also by conversion from alpha-pinene

[Fenaroli's Handbook of Flavor Ingredients. Volume 2. Edited, translated, and revised by T.E. Furia and N. Bellanca. 2nd ed. Cleveland: The Chemical Rubber Co., 1975., p. 486] **PEER REVIEWED**

FRACTIONAL DISTILLATION OF TURPENTINE; ISOMERIZATION OF ALPHA-PINENE

[SRI] **PEER REVIEWED**

Isolation of the d-form from *Ferula galbaniflua* Boiss. et Buhse, Umbelliferae

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 1283] **PEER REVIEWED**

Derived from sulfate wood turpentine

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 995] **PEER REVIEWED**

beta-Pinene is produced in large quantities by distillation of turpentine oils.

[Ullmann's Encyclopedia of Industrial Chemistry. 6th ed. Vol 1: Federal Republic of Germany: Wiley-VCH Verlag GmbH & Co. 2003 to Present, p. V14 100 (2003)] **PEER REVIEWED**

General Manufacturing Information:

Alcoholic beverages 9.64 ppm; Gelatins, puddings 9.77 ppm; Non-alcoholic beverages 11.24 ppm; Chewing gum 17.24 ppm; Condiments, relishes 20.00 ppm; Frozen dairy 20.12 ppm; Hard Candy 14.90 ppm; Meat products 8.81 ppm; Soft candy 20.34 ppm; Baked goods 26.12 ppm.

[Burdock, G.A. (ed.). Fenaroli's Handbook of Flavor Ingredients. 5th ed. Boca Raton, FL 2005, p. 1586] **PEER REVIEWED**

Flavors useful in: Spice flavors (nutmeg), citrus imitations

[Furia, T.E. (ed.). CRC Handbook of Food Additives. 2nd ed. Volume 2. Boca Raton, Florida: CRC Press, Inc., 1980., p. 298] **PEER REVIEWED**

Irreversible isomerization of beta-pinene to alpha-pinene occurs on shaking with platinum black saturated with hydrogen

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 1283] **PEER REVIEWED**

Formulations/Preparations:

Most commonly available as the l-isomer

[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994., p. 717] **PEER REVIEWED**

U. S. Production:

(1979) 2.15X10+10 GRAMS

[SRI] **PEER REVIEWED**

(1981) 2.04X10+10 GRAMS

[SRI] **PEER REVIEWED**

beta-Pinene is listed as a High Production Volume (HPV) chemical (65FR81686). Chemicals listed as HPV were produced in or imported into the U.S. in >1 million pounds in 1990 and/or 1994. The HPV list is based on the 1990 Inventory Update Rule. (IUR) (40 CFR part 710 subpart B; 51FR21438).

[EPA/Office of Pollution Prevention and Toxics; High Production Volume (HPV) Challenge Program. Available from the Database Query page at: <http://www.epa.gov/hpv/pubs/general/opptsrch.htm> on beta-Pinene (127-91-3) as of October 7, 2007] **PEER REVIEWED**

Production volumes for non-confidential chemicals reported under the Inventory Update Rule.

Year	Production Range (pounds)
1986	>10 million - 50 million
1990	>10 million - 50 million
1994	>10 million - 50 million
1998	>10 million - 50 million
2002	>10 million - 50 million

[US EPA; Non-confidential Production Volume Information Submitted by Companies for Chemicals Under the 1986-2002 Inventory Update Rule (IUR). beta-Pinene (127-91-3). Available from, as of October 7, 2008: <http://www.epa.gov/oppt/iur/tools/data/2002-vol.html> **PEER REVIEWED**

Laboratory Methods:

Analytic Laboratory Methods:

PINENES ARE DETERMINED IN AIR BY A HIGH-RESOLUTION IR INTERFEROMETER IN THE PARTS PER TRILLION RANGE AT 100 KM PATHLENGTH. THIS METHOD IS USEFUL IN DETERMINING THE BUILDUP OF PINENES IN AIR AT NIGHT WHEN PLANT EMISSIONS CONTINUE AFTER PHOTOCHEMICAL PROCESSES HAVE STOPPED.

[WILSON HW; INTEGRATED INFRARED GAS PHASE BAND INTENSITIES OF ALPHA- AND BETA-PINENES; JT CONF SENS ENVRION POLLUT, (CONF PROC), 4TH: 834 (1978)] **PEER REVIEWED**

/Pinene/ can be quantified using gas chromatographic procedures. /Pinene/

[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994., p. 1289] **PEER REVIEWED**

Method: NIOSH 1552, Issue 1; Procedure: gas chromatography with flame ionization detector; Analyte: beta-pinene; Matrix: air; Detection Limit: 0.4 ug/sample.

[CDC; NIOSH Manual of Analytical Methods, 4th ed. beta-Pinene (127-91-3). Available from, as of October 9, 2008:

<http://www.cdc.gov/niosh/docs/2003-154/> **PEER REVIEWED**

Special References:

Special Reports:

The Flavor and Fragrance High Production Volume Consortia; Revised Robust Summaries for Bicyclic Terpene Hydrocarbons Submitted to the EPA under the HPV Challenge Program. 202 pp. (November 9, 2006). Available from a search of <http://www.epa.gov/chemrtk/pubs/summaries/bictrphy/c13610tc.htm> as of October 8, 2008

Synonyms and Identifiers:

Synonyms:

BICYCLO(3.1.1)HEPTANE, 6,6-DIMETHYL-2-METHYLENE-

PEER REVIEWED

NOPINEN

PEER REVIEWED

NOPINENE

PEER REVIEWED

2(10)-PINENE

PEER REVIEWED

PSEUDOPINEN

PEER REVIEWED

PSEUDOPINENE

PEER REVIEWED

TEREBENTHENE

PEER REVIEWED

Associated Chemicals:

Beta-pinene (l);18172-67-3

Formulations/Preparations:

Most commonly available as the l-isomer

[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994., p. 717] **PEER REVIEWED**

Administrative Information:

Hazardous Substances Databank Number: 5615

Last Revision Date: 20090626

Last Review Date: Reviewed by SRP on 1/21/2009

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Field Update on 2007-04-19, 1 fields added/edited/deleted
Complete Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 10/31/2002, 1 field added/edited/deleted.
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Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 05/15/2001, 1 field added/edited/deleted.
Complete Update on 09/12/2000, 1 field added/edited/deleted.
Complete Update on 08/04/2000, 51 fields added/edited/deleted.
Field Update on 06/12/2000, 1 field added/edited/deleted.
Field Update on 06/12/2000, 1 field added/edited/deleted.
Field Update on 02/02/2000, 1 field added/edited/deleted.
Complete Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 08/27/1999, 1 field added/edited/deleted.
Complete Update on 06/03/1998, 1 field added/edited/deleted.
Complete Update on 03/19/1998, 5 fields added/edited/deleted.
Field Update on 03/10/1998, 1 field added/edited/deleted.
Field Update on 11/01/1997, 1 field added/edited/deleted.
Field Update on 05/09/1997, 1 field added/edited/deleted.
Field Update on 05/01/1997, 2 fields added/edited/deleted.
Field Update on 10/19/1996, 1 field added/edited/deleted.
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Field Update on 11/03/1994, 1 field added/edited/deleted.
Field Update on 11/02/1994, 1 field added/edited/deleted.
Complete Update on 04/04/1994, 1 field added/edited/deleted.
Field update on 01/09/1993, 1 field added/edited/deleted.
Complete Update on 10/10/1990, 1 field added/edited/deleted.
Complete Update on 04/16/1990, 3 fields added/edited/deleted.
Field update on 12/29/1989, 1 field added/edited/deleted.
Complete Update on 04/13/1989, 1 field added/edited/deleted.
Complete Update on 10/03/1986
Created 19830401 by SYS